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Report of the PSARC Salmon Subcommittee Meeting May 3-7, 1999

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SALMON

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SUMMARY

The PSARC Salmon Subcommittee met May 3-7, 1999 at the Pacific Biological Station in Nanaimo. External participants from the Pacific Fisheries Resource Conservation Council, the Fraser Aboriginal Fisheries Secretariat, the Pacific Salmon Harvesters Society, and the Sport Fishing Advisory Board attended the meeting.

Working Papers S99-9: 1999 assessment of Thompson River/Upper Fraser River Coho

The Subcommittee recommended that given the current low productivity of the Thompson coho aggregate, fishing mortality must be kept to a minimum to conserve and maximise the potential to rebuild these stocks.

The Subcommittee recommended completion of a policy paper on the role of enhancement in the conservation of salmon stocks for application to rebuilding Thompson coho stocks.

Working Paper S99-10: Assessment of coho stocks on the West Coast of Vancouver Island

The Subcommittee recommended a continuation of the cautious approach to managing fisheries that encounter WCVI coho given the uncertainty about the productivity and overall status of WCVI coho.

The Subcommittee recommended the Stock Assessment Data Group work with HEB Assessment to allow users accessing the MRP database to also access coded-wire tag escapement data from the HEB Escapement database

Working Paper S99-11: A review of hooking mortality rates for marine recreational coho and chinook salmon fisheries in British Columbia

The Subcommittee recommended that a Working Group be established with the mandate to further review the available information and recommend fishery and location-specific estimates of the release mortality effects of coho and chinook released from tidal recreational fisheries.

The Subcommittee recommended that existing sport monitoring programs should collect information on fishing methods to improve our understanding of area specific fishing practices.

Working Paper S99-12: Biological assessment of Skeena River coho salmon

The Subcommittee agreed with the authors' statement that the status of the upper Skeena river coho population remains poor.

The Subcommittee recommended that for Babine coho the high end of the range of 5,638 to 14,193 coho escapement above the Babine fence be used as an interim escapement target given the uncertainty in these estimates.

The Subcommittee recommended continuation of the research programs to develop standards for the estimation of Limit Reference Points for Babine (and other coho stocks).

Working Paper S99-13: Enhancement impacts on Cowichan River chinook

The Subcommittee recommended an evaluation of the utility of Cowichan chinook enhancement in the rebuilding of this stock.

The Subcommittee supported continued work to develop methods for assessing variance in CWT return data.

Working Paper S99-15: Optimal production of chinook salmon from the Taku River

The Subcommittee recommended 30,000 to 55,000 large spawners (not including jacks) as a range for Taku chinook target escapements for an interim five-year period and that a comprehensive review be conducted in 2003.

Working Paper S99-16: Optimal production of chinook salmon from the Stikine River

The Subcommittee recommended managing this stock to a maximum exploitation rate target of 30%, with a conservative escapement floor. The Subcommittee was unable to define the appropriate escapement floor because of the uncertainty in the data.

Working Paper S99-17: An assessment of Kitsumkalum River summer chinook, a north coast indicator stock

The Subcommittee recommended that the Kitsumkalum be maintained as a chinook exploitation rate indicator stock.

Working Paper S99-18: An evaluation of Okanagan sockeye escapement objectives

The Subcommittee recommended acceptance of this paper and the interim escapement objective of 60,000 sockeye through Wells Dam (which is equivalent to a historical Osoyoos visual estimate of 30,000 spawners).

Working Paper S99-19: Status of coho salmon stocks adjacent to the Strait of Georgia, including the lower Fraser River

The Subcommittee recommended that given the current low productivity of the Strait of Georgia-lower Fraser River coho aggregate, fishing mortality must be kept to a minimum to conserve and maximise the potential to rebuild these stocks.

Working Paper S99-20: Status of clockwork chum salmon stocks and review of the Clockwork Management Strategy

The Subcommittee recommended that the current overall ISC wild chum escapement goal of 2.0 million spawners remain in place.

The Subcommittee recommended that the previously revised PSARC minimum target escapement of 800,000 Fraser chum natural spawners be applied.

The Subcommittee recommended the review of 1) the adequacy of the In Season test fishery model to track stock abundance with an objective to find a more suitable protocol if the current model is deemed to be a failure. 2) the methodology of escapement enumeration on the Chehalis/Harrison system to ensure that unbiased and representative escapement enumeration's are indeed being generated.

Working Paper S99-21: Spawning capacity and harvest policies for Fraser River Sockeye

This paper did not evaluate the rebuilding policies of the last ten years but provided another overview of the current stock status and time trends in production. The strength of this paper was its treatment of uncertainty (Baysian methods) and the preliminary development of a policy evaluation framework. The Subcommittee noted the need for several papers for development of a comprehensive management plan for Fraser sockeye salmon.

INTRODUCTION

The Subcommittee Chair opened the meeting welcoming the participants. During the introductory remarks the objectives of the meeting were reviewed, and the Subcommittee accepted the meeting agenda (Appendix 1).

The Subcommittee reviewed 12 Working Papers. Working Paper titles, authors and reviewers are listed in Appendix 2. The meeting was attended by external participants and observers. A list of meeting participants is included as Appendix 3.

General Subcommittee Discussion and Concerns

1. The Subcommittee recommended that although there has been a marked improvement in recent escapement methodology and documentation in some areas it is essential that the regional escapement initiatives (to improve methods and documentation) are completed and implemented.

2. The Subcommittee noted the need to develop objectives and a conceptual approach for the management and assessment of each salmon species. This "assessment framework" is necessary to evaluate and compare prospective assessment programs within the context of the "New Direction for Canada's Pacific Salmon Fisheries" policy.

3. The Subcommittee reiterated the need to develop standard methods for coho juvenile abundance surveys. Juvenile abundance surveys are being conducted more extensively each year, both within and outside DFO. Standard methods must be used to ensure that results are comparable among studies and that conclusions are scientifically defensible.

4. The Subcommittee stressed the importance of completing the policy paper on the role of enhancement in stock rebuilding.

5. The Subcommittee noted the need to complete the wild salmon policy and the development of limit reference points for conservation.

6. The Subcommittee is concerned that the context of a number of PSARC papers was unclear and intent of the papers needs to be clarified when assigned. This was evident in the Fraser sockeye, Clockwork chum and Cowichan chinook working papers.

7. The Subcommittee noted that the uncertainty in all assessments increased as a result of the recent significant environmental changes in the ocean. The

ocean environment that juvenile salmon entered in 1998 was again unusual and this may affect subsequent returns.

WORKING PAPER SUMMARIES, REVIEWS AND DISCUSSION

S99-9 1999 Assessment of Thompson River/Upper Fraser River coho salmon

J. Irvine, R.E. Bailey, J. Till, K. Simpson, W. Luedke, P. Tschaplinski
Accepted subject to revisions

Summary

The working paper evaluated the effects of the 1998 fishing season on the status of upper Fraser/Thompson coho populations. Restrictions in Canadian fishery mortalities during 1998 lowered the overall exploitation rate to about 6% (2% in Canada), although estimates are not precise. Efforts to estimate spawner escapements in 1998 were greatly expanded over previous years, and we found that the upper Fraser/Thompson stock aggregate is larger than was previously thought. Based on methods of escapement estimation that were consistent with the historical data, there was a slight improvement in the aggregate escapement in 1998 over 1997, however many of the individual stream returns in 1998 were less than for the parent brood. No coho spawners were seen in many streams where they had been previously reported. The authors concluded that the status of South and North Thompson coho populations remains poor. The productivity of this portion of the aggregate has declined in the last 10 years to the point where the population is only barely able to sustain itself (even in the absence of fishing). Our understanding of the status of lower Thompson and non-Thompson/upper Fraser coho is weak.

Reviewer #1

The reviewer indicated that most of the paper was clearly written. The purpose, methods employed, and conclusions were readily understood, however, there were some issues needing more emphasis. These included the questionable quality of the escapement data, discussion of habitat quality in Thompson River tributaries, the estimate of coho encounters in Area 1 recreational fishery, the assumption that 20% of released fry survive to the smolt stage and the uncertainty in exploitation rate estimation. Also, the unknown changes in year-to-year freshwater conditions made comparisons of run size by brood year less credible and the discovery of additional coho systems in the upper Fraser made attempts to estimate impacts of fisheries on Thompson coho using DNA information problematic. The reviewer agreed with the conclusions of the paper but was uncertain as to their practicality or possibility of success and suggested that additional measures such as habitat restoration/protection should have been recommended.

Reviewer #2

The reviewer found the paper well written and well organised. Concerns identified included an inadequate discussion of coho catch monitoring programs and of the post-season estimation of stock composition generated by DNA analysis. The conclusions, while somewhat understated, were found to be defensible and consistent with the data and analysis. The reviewer recommended an analysis of the effects of varying exploitation rates on the mean time to extinction under a range of assumptions concerning productivity. The reviewer also suggested that further discussion on the adequacy of the existing estimates of catch, stock composition, catch and release mortality and escapement would be appropriate and would lead to clearer recommendations.

Subcommittee Discussion

The Subcommittee discussed the validity of the aggregate escapement trend given the problems with the accuracy of the individual system estimates. The authors felt that the aggregate trend was defensible as it mirrored the trend seen in some systems where escapements are known with some confidence. The problems of the regional escapement database were discussed at length with general agreement that improvements are needed (and to a large extent are underway). A related topic discussed covered the possible changes to the metapopulation structure as a result of loss of returns to individual systems. The increased survey intensity in 1998 confirmed the "zero" spawner counts previously recorded for some Thompson tributaries. The reappearance of fish in some of these areas, offered hope that recovery is possible should overall abundance improve.

The cost and feasibility of improving the exploitation rate estimate was discussed. The need for a planned, well-designed DNA collection program to improve stock composition of different fisheries was identified. Given the new coho distribution findings in the upper Fraser, the need for more baseline DNA analysis to differentiate between upper Fraser and Thompson coho was acknowledged. The cost of refining incidental mortality rates was also discussed. The senior author agreed to modify the table of the 1998 coho encounters and estimated mortalities so that estimates from the two methodologies are more comparable and to add a column providing the most appropriate of the two estimates.

The role of freshwater habitat problems in the decline of Thompson River coho was discussed. One author stated that the variability in escapement responses among systems was probably related to freshwater habitat problems but that the overall declines of the 1990s were related to ocean survival. Freshwater habitat degradation has occurred throughout the Thompson/upper Fraser. The degree of habitat change needs to be quantified for coho bearing streams and the

relationship between these changes and freshwater survival examined in detail.

The Subcommittee accepts that fishing regulations in 1998 resulted in approximately a 6% exploitation rate on upper Fraser/Thompson coho salmon (2% in Canada). The Subcommittee requested that in the future, the exploitation rates be expressed as a range with sources of errors detailed where possible.

DNA technology was relied upon to estimate numbers of Thompson coho in marine fisheries. To reduce uncertainty around estimates of fishery mortalities, the use of DNA to identify stocks of concern should be critically reviewed.

Expanded escapement surveys in 1998 relative to previous years identified significant populations of coho that were previously unknown. Some of these populations were in non-Thompson Fraser tributaries. However, based on consistent methods of escapement estimation there was only a slight improvement in escapements in 1998 compared to the 1995 brood year, and the status for South and North Thompson coho populations remains poor. The Subcommittee supports the continuation of the expanded escapement surveys.

Productivity of the North and South Thompson aggregates have declined in the past 10 years to the point where the populations' intrinsic rate of growth is near zero even in the absence of fishing. Since some coho populations within the North and South Thompson drainages appear to be at risk of extinction, fishing mortality should be minimised to conserve and maximise the prospects to rebuild these populations. The potential contribution of habitat restoration and enhancement in the rebuilding program needs to be evaluated. Unless there is a reversal in ocean conditions, the risks and conservation concerns will be even higher in 1999 than in 1998. This assessment is based on the facts that marine survival rates are expected to remain low, spawning populations in the brood year 1996 were lower than in brood year 1995, and there is concern that the reproductive potential of broods with small spawning populations may be lowered because of male-biased sex ratios and reductions in fecundity. There is a need to continue analytical work examining the risk of extinction of Thompson coho, incorporating information on habitat status, freshwater productivity, ocean survival and fishery impacts.

Subcommittee Recommendations

1) The Subcommittee recommended that given the current low productivity of the Thompson coho aggregate, fishing mortality must be kept to a minimum to conserve and maximise the potential to rebuild these stocks.

2) The Subcommittee recommended completion of a policy paper on the role of enhancement in the conservation of salmon stocks for application to rebuilding Thompson coho stocks.

S99-10 Assessment of coho stocks on the West Coast of Vancouver Island, 1998

S. Baillie, B. Patten, J. Till, K. Simpson, W. Luedke, P. Tschaplinski
Accepted subject to revisions

Summary

This working paper summarizes the abundance, exploitation rates and marine survival of coho stocks originating from streams on the west coast of Vancouver Island in 1998. Also included is a summary of the coho fry survey work that was completed in 1998. Returning adult coho salmon ('escapement') were either enumerated at counting weirs (e.g. Carnation Creek) or estimated from visual counts. The two wild indicators, Carnation and Kirby Creek, had coho adult escapements of 272 and 323 respectively. At the Stamp Falls Fishway 70,711 adult coho were counted. Of these, 36,658 returned to Robertson Hatchery and the rest (34,053) were considered as the 'wild' return. The increases over the brood year for Carnation Creek and Stamp Falls Fishway counts are 55% and 385% respectively. Visual surveys were conducted in 57 rivers and tributaries this year. The results indicate a 370% increase from the brood year. The exploitation rate for Robertson and Conuma Hatchery stocks was 1.9% (excluding freshwater fishery) and 1.2% respectively. The cessation of directed coho fishing has resulted in these rates dropping from recent years (they reached 75.5% in 1993). The marine survival for Robertson and Conuma Hatchery, and Carnation Creek stocks was 3.6%, 0.27%, and 5.6% respectively. Robertson Hatchery continues to slowly increase since the low survival year of 1994. Carnation Creek, the wild indicator, continues to fluctuate without a trend in the 5% - 10% range. Conuma Hatchery reached the lowest level since 1986, and was lower than the 1994 return of 0.28%. In 1998, 19 new fry survey sites were added in areas that have been under-represented in past years. Coho fry densities are trending upward in Area 24 and south, and stable in Area 25 and north.

Reviewer #1

The first reviewer was concerned about potential bias in the estimates of escapements of CWT coho returning to Robertson Creek, and the implications of this bias if it does occur. An analysis was undertaken to determine the degree of bias that could result if CWT coho surviving to return to Stamp Falls were not all enumerated. Historical exploitations may have been over-estimated by as much as 18%, and marine survival estimates underestimated by up to 5%. In part because Robertson Creek exploitations are used as a proxy for Carnation Creek coho, this issue needs to be addressed. The reviewer questioned the validity of 1998 exploitation rate estimates given recoveries reported for a WCVI marine sport fishery that did not take place. The reviewer went on to question whether fry density estimates can be compared among years without information on the comparability of, for example, sample sites and water levels among years.

Reviewer #2

The second reviewer was concerned that the authors had not established escapement (or other objectives) from which 1998 results for the WCVI coho stock aggregate could be compared. In addition, the reviewer noted the general absence of measures of uncertainty in the catch and escapement data.

Subcommittee Discussion

The Subcommittee requested the authors examine and clarify the potential bias from straying of Robertson Creek hatchery coho and the anomalous WCVI marine sport recoveries reported for 1998. The Subcommittee expressed concern over the low Conuma hatchery survival estimates for the 1995 brood, as it may reflect a change in estimation methodology (the use of 1998 MRP database returns to the hatchery compared to the normal practice of estimating Conuma escapement from the catch of Conuma CWT coho and exploitation rate for Robertson Creek coho.) The authors are requested to assess whether the 1998 Conuma escapement may be biased low.

The Subcommittee appreciated the presentation of additional results on juvenile density per metre by the authors and recommended the graph be included in the revised paper.

The Subcommittee was concerned over the lack of an explicit statement regarding the WCVI coho stock status, and its level of productivity. There was extensive discussion about the use of juvenile abundance data for measuring the status and productivity of wild coho stocks. However, issues such as the appropriate density standard to assess current abundance measures against, the appropriate methodology for survey site selection, survey timing, density measurement etc., were also of concern.

The Subcommittee noted that the 1998 PSARC assessment of WCVI coho had raised concerns regarding the status of Area 21 coho in light of a low measurement of juvenile density for Area 21 at that time. The Subcommittee asked the author to separate Area 21 escapement and juvenile data in the revised report in order to assess whether there have been improvements for Area 21 stocks

The Subcommittee agreed that marine survival of WCVI coho remains below average, although most streams experienced dramatic increases in coho escapement in 1998. The Subcommittee endorses extension of the WCVI escapement survey periods to more fully cover coho spawning migrations, and the continuation of coho fry surveys in 1999/00.

Subcommittee Recommendations

1) The Subcommittee recommended a continuation of the cautious approach to managing fisheries that encounter WCVI coho given the uncertainty about the productivity and overall status of WCVI coho.

2) The Subcommittee recommended the Stock Assessment Data Group work with HEB Assessment to allow users accessing the MRP database to also access coded-wire tag escapement data from the HEB Escapement database.

S99-11 A review of hooking mortality rates for marine recreational coho and chinook salmon fisheries in British Columbia

S. Cox-Rogers, T. Gjernes, E. Fast **Accepted subject to revisions**

Summary

This review examines hooking mortality rates for marine recreational coho and chinook salmon fisheries in British Columbia. Hooking mortality results from non-harvest fishing and refers to the proportion of fish dying after being captured and then released. Based on the results of studies conducted from California to Alaska, it is evident that hooking mortality can be quite variable for the same salmon species captured on similar gears in different areas. Hooking mortality for coho and chinook in marine recreational fisheries varies from 5% to over 30% along the Pacific coast. Hooking mortality is influenced by a wide range of factors including fishing technique, fish species, fish size, fish behaviour and aggressiveness, food availability, fish abundance, stage of maturity, temperature/season, depth of capture, hook size and type, and angler skill in playing, landing, and releasing.

With respect to British Columbia marine recreational chinook and coho fisheries, the currently applied hooking mortality rates of 10% for coho and 15% for chinook are not gear or method specific, do not include a drop-off or long-term mortality component, and are applied equally to all fisheries coastwide. From a fishery impact (e.g. modeling of exploitation rates) perspective, this approach is probably not appropriate, as the actual impacts of catch and release fishing may be underestimated or overestimated with these rates depending upon the fishery in question. As with findings recently noted in U.S waters, hooking mortality rates in marine recreational fisheries in British Columbia are likely dependent upon the gear, the period, and the method of fishing used. In general, less active forms of fishing (i.e. mooching), appear associated with higher hooking mortality rates, while more active forms of fishing (e.g. trolling) appear associated with lower hooking mortality rates. To accurately characterize mortalities in British Columbia marine recreational fisheries, it will be necessary to measure encounters by gear and method type and apply a mortality rate appropriate to the gear and methods actually being used. Where there are no estimates of hooking mortality rates for

a particular gear, or where local variations of fishing method may lead to different rates, it may also be necessary to conduct additional studies to establish appropriate values.

Reviewer #1

The first reviewer indicated that in general the paper does a good job of setting out the current knowledge of hooking mortality rates for coho and chinook in tidal waters. The reviewer notes that the paper reports mortality rates but does not critically review them. The reviewer provided very detailed comments for suggested improvements throughout the paper. Concern was expressed over the inclusion of data from areas or species that may not apply to British Columbia fisheries.

Reviewer #2

The second reviewer noted the paper was unusual in that it was a review and not an assessment. The information presented was useful and imparts the point that a single hooking mortality rate region wide is probably not appropriate. Our present method of applying hooking mortality rates to the recreational fishery does not take into account differences in fishing techniques. The reviewer recommended that PSARC form a committee to review all available information on recreational hooking mortality rates and to recommend appropriate rates to use in stock assessment studies.

Subcommittee Discussion

The Salmon Subcommittee complimented the authors on a well-researched paper. They appreciated the assembly of data from such a variety of sources. However, they did comment that additional information is available and should be examined and incorporated in future work if appropriate (e.g. DFO Stock Status Report on Atlantic Salmon hooking mortalities; work on chinook and coho hooking mortalities in the Great Lakes).

The Subcommittee emphasized the importance of understanding the impact of fisheries on overall mortality or reduced fitness (e.g., spawning success), not just the short term mortality summarised in this paper. It noted that the coastwide hooking mortality rates currently used do not incorporate non-landed mortality. Within the Strait of Georgia and elsewhere, marine mammal effects on salmon mortality during angling may be significant. Again, data are available and some analytical work has been done which the authors should consider.

The Subcommittee discussed and endorsed the authors conclusion that for British Columbia marine recreational fisheries, hooking mortality for coho and chinook is likely dependent upon the gear and methods used, and assumed hooking mortality rates for coho and chinook assessment/management modeling should take into account differences in gear and fishing methods.

The Subcommittee supported the need for programs to quantify gear and method specific hooking mortality rates for coho and chinook in major marine recreational fisheries where the information is lacking. However, the need to refine estimates of hooking mortality depend on a larger context of uncertainty about total mortality. The value of additional research on hooking mortality should first be assessed by simple sensitivity analysis. Fishery specific analyses were recommended as a way to evaluate whether further research and monitoring of hooking mortality was warranted.

The Subcommittee noted that parallel technical reviews are currently underway in the U.S. and joint efforts to resolve the technical aspects of these issues are encouraged.

The Subcommittee noted that the need to define release mortality rates and long term impacts also applies to freshwater recreational fisheries, and all of the methods used in commercial and First Nations fisheries. Analyses to evaluate the implications of various assumed rates in these fisheries should be undertaken.

Subcommittee Recommendations

1) The Subcommittee recommended that a Working Group be established with the mandate of further reviewing the available information and recommending fishery and location-specific estimates of the release mortality effects of coho and chinook released from tidal recreational fisheries.

2) The Subcommittee recommended that existing sport monitoring programs should collect information on fishing methods, to improve our understanding of area specific fishing practices.

S99-12 Biological assessment of Skeena River coho salmon

B. Holtby, B. Finnegan, D. Peacock **Accepted subject to revisions.**

Summary

Marine survivals were higher in the 1997-sea entry than they had been in the 1996-entry year. The increase relative to the previous year was largest for Toboggan wild and hatchery smolts but was slight for Fort Babine smolts. Survival was average for Lachmach coho but was below average for both Toboggan hatchery and wild smolts. There is growing evidence that apparent hatchery survivals are less than 30% of wild survivals.

Exploitation rates ranged between 28% for Toboggan coho to 60% for Babine coho. Exploitation in Canadian fisheries, due entirely to small incidental catches and release mortality, was reduced to less than 1.5% for all fisheries. Exploitation rates in Alaskan fisheries remained largely unchanged from recent years.

Juvenile densities in 1998 provided a complex picture of 1997 escapement. Juvenile densities were lower in 1998 than in 1997 in five of eight summary areas. The largest decrease was seen in the upper Skeena (0.12×). No juvenile coho were detected in the Sustut River sites despite an expanded search; very few juveniles and no young of the year were detected in the upper Bulkley. Decreases in the middle Skeena areas and the Bulkley/Morice ranged from 0.59× to 0.68×. Large increases were seen in the Lachmach (1.7×) and the coastal streams (1.8×). Juvenile densities also increased in the Babine by a factor of 1.3×. This increase was general throughout the Babine. Despite the increase, juvenile densities in the Babine system remained well below levels we would interpret as indicating an adequately seeded system.

Escapement in 1998 was much improved throughout the Skeena Basin. The test-fishery index to August 25th was about the 29th percentile in a 43-year time series. The index value was similar to values seen in the 1980s. However, the value is consistent with a simple transfer of catch to escapement. Escapement to the Babine was 4,291 or over 9-times the escapement in 1997. Compared to historic escapement, the value in 1998 was at the 34th percentile, which is significantly less than the median and is again comparable to escapement in the 1980s and early 1990s. However, total stock size was lower than the brood years and did not represent a departure from the downward trend in stock size that began sometime in the 1970s. Visual escapement indices increased relative to 1997 in all Statistical Areas except Area 5. The largest proportional increase was in the upper Skeena (13.9×) but only six streams were included in the index. More escapement work in the upper Skeena would be required to have increased confidence in the visual escapement index. Escapement to the Bulkley/Morice above Moricetown falls was 23,000 or 3.5-times the 1997 escapement. With only four observations but covering a very wide range of escapement, the Moricetown estimate is significantly correlated with the Skeena test-fishery index (unadjusted). Tagging at this site could potentially yield escapement estimates for Morice pink, Nanika/Morice sockeye and Bulkley/Morice chinook. The coho-tagging program should become a core assessment program. Escapement to the upper Bulkley increased from 88 in 1997 to 317, an increase of 3.6×. However, escapement to the upper Bulkley remains less than 10% of historic averages.

A new index site on the Sustut River was introduced in this report. Coho escapement there increased to 64 from 5 (all males) in 1997 but was only 46% of the escapement in the dominant brood year (1994). Historic data from this area is very unreliable but habitat measures suggest that current escapements are less than 10% of carrying capacity. Overall, the escapement measures present a

consistent picture of the status of Skeena Basin coho. Although escapement improved throughout the Basin, status remains very poor in the high interior and the upper Bulkley and well below carrying capacity throughout the interior. Coastal and middle Skeena areas appear to have recovered to average levels. The reappearance of fish in all areas is an encouraging sign that recovery is possible.

Very simple characterizations of average productivity for the Statistical Area aggregates and for the indicator streams confirm large productivity differences between interior streams (and Area 6) and streams in the lower and middle Skeena, Area 3 and SE Alaska. It is apparent that relative productivity is strongly related to population and aggregate status, as measured by two measures of status. This is compelling evidence that the root cause of declines in coho abundance in the Skeena interior is a chronic mismatch of exploitation rate and productivity.

A simple simulation of future population size for Babine coho indicated that recovery is contingent on both future survival and exploitation rates. With fishing levels similar to those in 1998 and a continuation of present survivals, slow recovery to escapement near carrying capacity is expected. With average fishing rates, recovery is uncertain unless survivals improve substantially.

Finally, a provisional escapement target to the Babine of 12,500 is suggested. At average survival the corresponding exploitation rate would be approximately 50%. A Limit Reference Point (LRP) Escapement[1] of 1,400 is also provided.

Reviewer #1

The first reviewer commended the authors on assembling all of the available data and in providing a comprehensive picture of Northern coho. It was felt that most of the conclusions of the Working Paper were supported by the data and methods. The notable exception was the recommendation for target escapement levels and harvest rates for the Babine complex. The reviewer noted that there was a significant discrepancy between the habitat-based and stock-recruit approaches which will have to be reconciled before the target escapements could be considered credible.

Reviewer #2

The most significant comment made by the second reviewer was that the basis for the LRP escapement of 1,400 fish was weak, and that this LRP should not be accepted. The reviewer noted that the paper was difficult to follow in places, and that recommendations could have been made clearer. There was also concern expressed about the counter-intuitive results from some of the fry survey information.

[1] Escapement should not be allowed to fall below this level.

Subcommittee Discussion

The Subcommittee agreed with the authors that the status of the upper Skeena river coho populations remains poor although returns to the Skeena watershed improved in 1998 relative to 1997.

The Subcommittee considered the Limit Reference Point (LRP) escapement for the Babine complex of 1,400 fish to be provisional. It was pointed out that at least two approaches to developing LRP's are being developed by the Department of Fisheries and Oceans: these involve using stock-recruit or habitat data to develop LRP's based on theoretical models of population dynamics, and empirically-derived LRP's based on evidence of recovery from a historical minimum abundance. It was noted that many of the elements required for the various approaches are contained in this Working Paper. The Subcommittee noted there may be an opportunity for a coordinated approach between the Department of Fisheries and Oceans and the B.C. Ministries of Fisheries and Environment, Land and Parks on this issue.

The authors developed a number of estimates of target or optimal escapements for the Babine complex that were based either on stock-recruit or habitat data. These estimates ranged from 5,638-14,193 spawners, depending on the assumptions made. The Subcommittee felt that the target escapements based on stock-recruit data (8,735) was likely biased low. One reviewer noted that the habitat-based estimates might also be biased low because of assumptions made in the author's calculations.

An external participant noted that estimates of optimal exploitation rates made by standard stock-recruit analysis are often 5-8% higher than those that are optimal for a typical mix of coho populations that vary in productivity. Thus, the long-term sustainable exploitation rate for the Babine complex (once the stock has recovered) may only be in the range of 55%. This is considerably lower than what the stock had experienced over the last two decades.

Subcommittee Recommendations

1) The Subcommittee agreed with the authors' statement that the status of the upper Skeena river coho population remains poor.

2) The Subcommittee recommended that for Babine coho the high end of the range of 5,638 to 14,193 coho escapement above the Babine fence be used as an interim target given the uncertainty in these estimates.

3) The Subcommittee recommended continuation of the research programs to develop standards for the estimation of Limit Reference Points for Babine (and other coho stocks).

S99-13 Enhancement Impacts on Cowichan River chinook

R.G. Bonnell, S. Lehmann, D. Nagtegaal **Accepted subject to revisions.**

Summary

Chinook salmon (*Oncorhynchus tshawytscha*) are an important species to commercial, sport and native fisheries in British Columbia. In 1985, a chinook rebuilding plan was initiated through the Pacific Salmon Treaty (PST) between the United States and Canada in response to a perceived decline in chinook stocks in the southern portion of the Strait of Georgia. The Cowichan River system was selected as one of the indicator stocks for assessing lower Strait of Georgia (LGS) chinook stock responses to changes in harvest management and rebuilding strategies. The two other indicator stocks selected were Squamish and Nanaimo.

The rebuilding plan for LGS chinook, required all parties to reverse the decline in escapement of naturally spawning chinook stocks and to attain escapement goals in selected indicators by 1998 (Pacific Salmon Commission, 1987). The plan established catch limits in mixed-stock chinook fisheries and harvest rate controls in other fisheries to increase escapement to the spawning grounds. In response to continued declines in escapement, a Technical Working Group was struck in 1987. Further conservation measures were introduced to reduce harvest rates. In addition, a plan was implemented for the rebuilding of LGS indicator stocks, which incorporated enhancement guidelines and increased targets.

A Salmonid Enhancement Program (SEP) hatchery has been in operation on the Cowichan River since 1976. Initial enhancement focussed on chum and salvaged coho fry. Enhancement of chinook began in 1979. The facility was expanded between 1987 and 1992 to help meet the rebuilding objectives. In addition, some 1986 brood Cowichan chinook were reared to maturity to provide additional eggs to speed up the rebuilding process.

The status of the indicator stocks and evaluation of the rebuilding plan in meeting the objectives is reported annually to the Pacific Stock Assessment Review Committee (PSARC). The 1998 PSARC review (Stocker & Peacock, 1998) of the stock status of Cowichan chinook salmon recommended that the impact of enhancement on the natural chinook population be assessed and that a review of enhancement procedures and outcomes be initiated. The purpose of this paper is to review the results of the enhancement strategies employed to date and their outcome in terms of the original LGS objectives.

Reviewer #1

The first reviewer found the paper to be well written and addressed the objective, but stated it did not substantively address the previous PSARC request to evaluate the impact of enhancement on the natural chinook population. Although the paper was not asked to evaluate how many adults returned to the river from enhancement compared to how many would have been produced if the fish spawned naturally, it should have estimated the incremental benefit of enhancement.

The reviewer questioned why the HEB Escapement database was used to analyze escapements rather than the MRP database?

It was recommended that enhanced survival to escapement should be compared with wild survival to escapement in order to compare return per brood stock female versus return per wild spawner, and the difference used to assess enhancement.

There is good anecdotal evidence of residualization of lakepen chinook, and with the apparent poor survival, there seems good reason to reduce or eliminate this strategy. There needs to be more information for the authors' preference of lakepen over seapen rearing strategy.

Reviewer #2

The second reviewer commented that although the data on contribution and survival rates are summarized in easy to follow tables, the estimated tag recovery data by strata, return year and tag code should be included. The methodologies, data, and results for escapement and hatchery contribution analyses in this report should be compared to those used in previous Cowichan stock status reports. The various reported escapement targets from 11,250 to 12,500 also need clarification as this is key to the size of the allowable enhanced component. The reviewer indicated that although there was a thorough discussion of some release strategies the rationale behind the lower release strategy, or the captive brood stock, should have been more detailed.

The reviewer felt that the data in the paper supported the conclusion that enhancement had not exceeded 50% of the escapement except in 1995, and supported other methods such as otolith markings being used to estimate the proportion enhanced. Finally, the reviewer felt that a discussion about the problems and lessons learned in operationalizing the enhancement guidelines and targets, and how to develop guidelines, performance measures, and objectives for other programs of this nature, would be a useful addition.

Subcommittee Discussion

The Subcommittee discussed whether the paper reflected the original PSARC recommendation that the impact of enhancement on the natural chinook population be assessed, and that a review of enhancement procedures and outcomes be initiated. It appears that the second part of the recommendation may have been addressed but not the first part. There needs to be an assessment of the foregone natural production of the brood removals as well as, incremental production of enhanced fish spawning naturally. The author agreed that this should be done and agreed to supply the brood removal numbers but thought that the analysis might be more the jurisdiction of Stock Assessment.

There was some clarification of the PSC chinook rebuilding targets for the Cowichan; 11,250 was a doubling of the 1979-82 average escapement and 14,000 was this goal plus a terminal native harvest; but the origin of the 12,500 is unclear.

The authors clarified that the HEB escapement database was used because MRP only includes estimated recoveries where escapement estimates are highly reliable such as with fence counts. The MRP database also does not allow expansions by sex. There is a need to clarify the differences and to provide user access to the appropriate databases.

The Subcommittee had further discussion on the difficulty in determining CWT variances. Although there has been some progress there are still no accepted methods for computing variances for CWT data.

The Subcommittee agreed that the recommendation to establish the productive capacity of Cowichan chinook and set new escapement and enhancement contribution targets should be addressed first. This would then be followed by consultation with the community and stakeholders about future plans if there are to be major changes to enhancement targets. That would follow a further review of the best enhancement strategies to meet these targets.

The Subcommittee agreed that from the data presented, there was insufficient evidence of any statistical difference in survival among the various rearing strategies. Rationale for reducing or eliminating some strategies may have other biological or operational reasons such as residualization of lakepen releases, or interaction with wild fry, or benefits versus costs but these should be clearly presented in the paper if they are to be recommended.

The Subcommittee understands that there is evidence of a natural mark on Cowichan chinook otoliths that appears to allow separation of enhanced from natural chinook. This work should be pursued further before recommending thermal or otolith marking.

The Subcommittee supported continued work to develop methods for assessing variance in CWT return data.

Subcommittee Recommendations

1) The Subcommittee recommended an evaluation of the utility of Cowichan chinook enhancement in the rebuilding of this stock.

2) The Subcommittee supported continued work to develop methods for assessing variance in CWT return data

S99-15 Optimal production of chinook salmon from the Taku River

S.A. McPherson, D.R. Bernard, J.H. Clark **Accepted subject to revisions**

Summary

Optimal production of adult chinook salmon *Oncorhynchus tshawytscha* from the Taku River was investigated with information from a stock assessment program (1973-1997) and catch sampling programs of the Canadian inriver gillnet fishery, U.S. gillnet fishery in Taku Inlet, the U.S. commercial troll and the U.S. recreational fishery near Juneau. Stock assessment was based on aerial surveys and mark-recapture experiments to estimate abundance of large (mostly age 1.3 and older) salmon over the spawning grounds. Relative age composition was estimated from 1973 through 1997 at a carcass weir on the Nakina River and during mark-recapture experiments on other tributaries. Additional mark-recapture experiments using coded-wire tags provided estimates of harvest in fisheries and abundance of emigrating smolts. Spawning abundance that would produce maximum-sustained yield (N_{MSY}) was estimated at 19,597 and 28,738 large salmon from fits of two traditional stock-recruit models to the data. No auto correlation among residuals was detected in these fits, however, measurement error in estimates of spawning abundance and production, mostly from aerial surveys, reduced confidence in the accuracy of these estimates of N_{MSY} . Inspection of more precise, individual estimates of spawner and smolt abundance, adult production, and smolt size provided evidence for early density-dependent survival of young salmon and later density-independent survival of young salmon while still in freshwater and while at sea. Because observed smolt production was near maximum over a range of about 30,000 to 55,000 large spawners, this level was recommended as the best estimate for N_{MSY} at this time. We recommend that the Alaska Department of Fish and Game and the Department of Fisheries and Oceans (Canada) adopt a biological escapement goal range of 30,000 to 55,000 large spawners for management purposes for this chinook salmon stock. We also recommend continuation of several stock assessment activities to improve estimation of population statistics and to

improve management of this stock.

Reviewer #1

The reviewer questioned whether the data was adequate to support the analysis and conclusions. Specific concerns were raised regarding the technique used to estimate spawning escapement in years without a mark-recapture program. The reviewer suggested an escapement range of 20,000 to 30,000 be adopted as an interim value. The recommendations to continue the mark-recapture, aerial escapement, biological sampling and smolt tagging programs were supported. In addition, the reviewer suggested a genetic sampling program to evaluate the potential application of this technique.

Reviewer #2

The reviewer indicated that this document provides a comprehensive description of the biological data available to assess this stock of spring chinook salmon. The report is generally well written and provides good summaries of the data and analyses in appendices. While the authors conduct "typical" stock/recruitment analyses of these data, they subsequently conclude that the results are "suspect" due to measurement error and rely on auxiliary information to determine a management range for spawning escapement.

Based on the stock/recruitment analyses presented, a range of escapements for maximum sustained yield would be 19,600 (Beverton-Holt model) to 28,700 (Ricker model) assuming 1:1 sex ratio. Our review of these data agree with the authors' results (compared for the Ricker model only), indicating an MSY escapement of 29,900 spawners (1:1 sex ratio) and high uncertainty in the estimate. A bootstrap assessment (n = 1000) of the analysis resulted in:

	1st. Quartile	Median	Mean	3rd. Quartile
Females only	11,240	13,800	10,420	18,250
Females/0.5	22,480	27,600	20,840	36.500

Given the authors comments on error in these data and the biases typical of these analyses, these values are very likely to be conservative (low).

The authors' recommended management range of 30K to 55K large chinook spawners could result in a management goal of about one half of the existing target (if a mid-point.) Since the data are still weak for determining this range, the reviewer was concerned about such a reduction as a response to this assessment. The reviewer suggested varying the escapement with return size to achieve results throughout the range. The reviewer recommended endorsing this range of escapements for an interim five-year period and that a comprehensive review of this range be conducted in 2003. This would allow the returns from recent large escapements to be evaluated to better define the production limits in

this system.

The recommendations to continue assessment work as outlined in this paper were endorsed by the reviewer. Increased attention could be given to collecting representative biological sampling data for age-sex-size of returning chinook, both in the fisheries and the spawning escapements.

Subcommittee Discussion

The Subcommittee discussed concerns regarding the quality of the escapement information, and supported the continuation of both the mark-recapture escapement enumeration and the escapement aerial surveys to refine estimates of the variability in expansion factors. The Subcommittee supported the continuation of the biological sampling programs, and the smolt production estimates.

Based on the stock/recruitment analyses presented, a range of escapements for maximum sustained yield would be 19,600 (Beverton-Holt model) to 28,700 (Ricker model) assuming 1:1 sex ratio. The Subcommittee noted that given the authors comments on error in these data and the biases typical of these analyses, these values are very likely to be conservative (low). The Subcommittee indicated the productivity of this system was poorly defined by the available data but accepted the range of 30,000 to 55,000 as a conservative definition of the target escapement range. The Subcommittee noted that recent escapements in 1996 and 1997 were very large (81,000 and 115,000) and returns from these broods should help define the productivity of the system.

Subcommittee Recommendations

The Subcommittee recommended 30,000 to 55,000 large spawners (not including jacks) as a range for Taku chinook target escapements for an interim five-year period and that a comprehensive review be conducted in 2003.

S99-16 Optimal production of chinook salmon from the Stikine River

D.R. Bernard, S. A. McPherson, K.A. Pahlke, P. Etherton **Accepted subject to revisions**

Summary

Optimal production of adult chinook salmon *Oncorhynchus tshawytscha* from the Stikine River was investigated with information from a stock assessment program (1975-1997) and catch sampling programs on the Canadian inriver commercial and aboriginal gillnet fisheries and on the U.S. marine commercial gillnet and recreational fisheries. Stock assessment was based on aerial surveys, mark-recapture experiments to estimate abundance of large (mostly age 1.3 and older)

salmon over the spawning grounds, a weir over the Little Tahltan River, and a radiotelemetry study to determine distribution of spawning salmon. Counts at the weir represented on average an estimated 19% of all large spawners in the watershed; counts from aerial surveys represented on average an estimated 48% or 36% of large fish above the weir depending on water clarity. Estimates of relative age composition from carcass surveys (1981 – 1988) on the Little Tahltan River were similar to estimates from samples taken at the weir (1985 – 1997). Few age 1.2 salmon were present over the spawning grounds; salmon age 1.4 usually dominated. Measurement error in estimated spawning abundance was an estimated 9% of all variance. Residuals from a fit of a linearized, log-transformed version of Ricker's exponential stock-recruit model to the data showed no autocorrelation in process error. Spawning abundance that would on average produce maximum sustained yield was estimated at 15,616 large chinook salmon with simulated 95% confidence intervals of 11,272 and 35,435. Some statistical bias (~15%) was indicated in the estimate. Considering that estimated spawning abundance has been above 15,616 large chinook salmon since 1986, the authors concluded that this population has recovered from overfishing incurred in the 1970s. Considering other circumstances of the investigation, the authors recommended annual aerial surveys be suspended, and the coded-wire tag program to estimate marine harvests and smolt abundance be reinstated.

Review #1

The first reviewer found no compelling reason to believe that the recommended escapement goal range is optimal for the Stikine. Considering the statistical uncertainties, a wide range of stock- recruit relationships are consistent with the available data. Optimum escapements could easily be much higher than the proposed range.

Review #2

The second reviewer reanalyzed the stock and recruit data and noted that the stock recruit curve fitted to the weighted data (as used by the authors) did not fit the data as well as the curve fit to the unweighted data. Fitting the curve to the weighted data should reduce the effect of measurement error. Since it did not, the reviewer questioned the variance calculations for both the stock and recruit data. The second reviewer noted that not only were both the weighted and standard Ricker curve fits not significant, but that a linear regression was significant. The second reviewer recommended retaining the existing escapement goal range until more data (recruits produced by larger spawning stocks) are available.

While both reviewers were impressed with the work involved in assembling the stock and recruit data for Stikine chinook, both reviewers also expressed concerns regarding the uncertainty of this analysis.

Subcommittee Discussion

Only 15 data points and a wide range of recruits produced by similar numbers of spawners leads to considerable uncertainly in any assessment of the productivity of Stikine chinook. An escapement goal range based on such an analysis stands a good chance of being low.

The Subcommittee could not support the conclusion that the Stikine chinook have apparently recovered from overfishing in the 1970s, because of the uncertainty in the data. The working paper recommendation to eliminate the aerial surveys was supported. The Subcommittee acknowledged that a CWT program would clarify current marine exploitation rates and provide valuable data to partition freshwater and marine survival.

As an alternative to a poorly defined escapement goal, the Subcommittee recommended an escapement floor combined with an exploitation rate objective. This approach will lead to a wider range of escapements that in turn will improve our assessment of productivity. Stock-recruit analysis conducted during the meeting using SRshow software suggests an optimum exploitation of 32% (Carl Walters, University of British Columbia, personal communication).

Subcommittee Recommendations

The Subcommittee recommended managing this stock to a maximum exploitation rate target of 30%, with a conservative escapement floor. The Subcommittee was unable to define the appropriate escapement floor because of the uncertainty in the data.

S99-17 An assessment of Kitsumkalum River summer chinook, a north coast indicator stock

R.E. McNicol **Accepted subject to major revisions**

Summary

In 1984, the Kitsumkalum River summer chinook stock was chosen for monitoring under the chinook 'key-stream' program, which was initiated in responses to objectives set out in the Canada-U.S. Pacific Salmon Treaty. The goal was to use escapement and exploitation information from this stock as an indicator of harvest and exploitation rates on B.C. north coast chinook. This paper is the first comprehensive review of these data since the start of the program.

Since 1984, escapement of this stock has varied between 5 and 24 thousand fish, with peak abundance occurring from 1987-1990. While brood exploitation

rates on this stock have ranged from 33-62%, the small changes in age structure of the escapement since 1984 suggest that this stock has not been overexploited. Poor fry-to-age-two survival contributed to low escapement in 1991 and 1995. However, it is not known whether this was the result of poor early freshwater or early marine conditions. Circumstantial evidence suggests that the low 1991 and 1997 escapements were at least in part the result of high mortality during the egg-to-fry stage of the contributing wild broods. However, there are no fry abundance estimates available to confirm this.

Escapement to this system generally did not correlate well with most other Skeena chinook stocks, or the adult test fishery index. However, exploitation patterns for this stock appear to be similar to those of other Skeena summer stocks. While biological sampling and escapement CWT samples have been poor some years, suggested changes to the program should address most of these problems in the future. Consequently, it is recommended that this program continue. In addition, it is suggested that fry monitoring and hatchery smolt release programs be implemented on this river to provide separate estimates of early freshwater and early marine survival. Such programs will aid in identifying environmental factors influencing production of north coast chinook.

Reviewer #1

The reviewer found the paper to be accurate and comprehensive, but expressed concerns with using Kitsumkalum as an indicator for other Skeena Chinook stocks. While there may be good reason to continue using Kitsumkalum Chinook as an exploitation indicator for summer run stocks, there is a need to establish an indicator for early run timing chinook stocks. The reviewer felt there was a weak correlation between chinook escapement to the Kitsumkalum and other Skeena chinook stocks, and found no correlation with the catch of adult chinook in the test fishery. A further review is needed to assess all northern summer run stocks to determine whether a more suitable indicator stock can be identified.

Reviewer #2

Reviewer 2 felt the paper did a good job of evaluating stock status by including data on escapement trends, harvest, exploitation rates, and stock-recruitment. There needs to be more discussion of acceptable exploitation rates in light of the stock recruitment relationship and current low returns. Data on incubation and freshwater rearing survival are unavailable so it is difficult to evaluate the factors causing the low returns. An evaluation is required to analyze the tag and recovery program to determine whether the escapements were within acceptable limits, including tag and recovery biases and recommendations on how to improve the program. Double tagging should be considered. Improvements are needed to the tag and recovery program to increase the reliability of the escapement estimates and recover more CWT's. Confidence limits need to be determined around the escapement CWT data and whether this was statistically

adequate to measure changes in fishery harvest and exploitation rates for this stock. This evaluation should determine whether this stock can be used to represent other North coast chinook stocks.

Subcommittee Discussion

The precision of survival and exploitation rate estimates are limited by the low survival rate of CWT chinook fry released into the Kitsumkalum River, which results in low numbers of tags being recovered. Another shortcoming of the current fry release program is that freshwater (fry to smolt) and marine survival rates cannot be estimated independently.

The precision of exploitation rate estimates could be improved by releasing more marked fish. The Kitsumkalum hatchery has space to rear an additional 50,000 fry for an annual total of 250,000. These additional fish could be released as fry to improve estimates of exploitation, or held and released as yearlings to obtain an estimate of marine survival that could reasonably be expected to represent other Skeena and north coast chinook stocks. The Subcommittee also agrees that implementation of a juvenile monitoring program to estimate early freshwater survival and fry production would be beneficial. However, the yearling tagging should be a higher priority since we currently have no ability to measure marine survival for North Coast chinook.

Stock-recruit analysis conducted during the meeting using SRshow software suggests an optimum exploitation of 32% similar to the results for the Taku and Stikine chinook stocks (Carl Walters, University of British Columbia, personal communication). The most likely optimum spawning stock is about 9,000 spawners, but this is highly uncertain (the optimum could be much larger). The Subcommittee noted that the current exploitation rate should not be increased, and may be too high based on this preliminary assessment.

The Subcommittee recommended that the Kitsumkalum be maintained as an indicator stream because it's timing is coincident with the other major Skeena chinook stocks. The Subcommittee noted the low correlation between the Kitsumkalum spawner estimates and estimates for other Skeena tributaries, but also recognized the questionable reliability of the escapement estimates to other systems. Caution should be used in applying the information from this indicator stock to other Skeena stocks with different timing, and to other northern chinook stocks. Even within the Skeena, correlations among escapement trends diminish as geographical distance between stocks increase, suggesting that local freshwater events (affecting fry to smolt survival) play a large role in determining overall survival of the stock.

The Subcommittee noted there is a need for continued development of management assessment frameworks for chinook and other species to provide direction on the merits of implementing additional indicator stocks.

Subcommittee Recommendations

The Subcommittee recommended that the Kitsumkalum be maintained as a chinook exploitation rate indicator stock.

S99-18 An evaluation of Okanagan sockeye escapement objectives

K. Hyatt, D.P. Rankin, D. Nagtegaal **Accepted subject to revisions.**

Summary

Information from both historic and recent assessment activities has been assembled in this report to determine the current status of Okanagan sockeye. Subsets of the information are then used to: 1) evaluate the utility of historic escapement data, 2) identify factors that may limit stock production within the Okanagan Basin and 3) identify escapement objectives that are consistent with what is known about spawning and rearing habitat limitations in the Okanagan River and Osoyoos Lake.

Okanagan sockeye stock production is not large (average return of 56,147 sockeye per annum; range 1,666-199,832) compared to that found in other areas on the B.C. coast, but is very important locally to meet ceremonial and subsistence needs of First Nations people of the U.S. and Canadian portions of the Columbia and Okanagan River basins. Returns, averaging 18,148 adult sockeye per year in the current decade, are the lowest for any decade within the 45 year period of record for the stock. In addition, spawner abundance has declined to match record lows in 3 of the past 5 years and has stimulated expressions of concern by fisheries personnel and resource stakeholders about future prospects for long term persistence of Okanagan sockeye.

Analysis of spawning habitat capacity in terms of quantity and quality of gravel available for redds and egg incubation indicated that the Upper Okanagan River could accommodate several times the number of spawners that currently return annually. Similarly, analysis of rearing habitat in Osoyoos Lake based on both its nutrient status (total phosphorus load) and limits placed on sockeye use by changes in seasonal water quality parameters (temperature and oxygen levels) suggests that Osoyoos Lake has ample capacity to support good growth and survival of fry from no fewer than 58,730 spawners (as enumerated at Wells Dam). Analysis for possible associations between annual variations in spawner abundance and subsequent production variations of both smolt numbers and biomass also supports conclusions that neither spawning habitat in the Okanagan River or rearing habitat in Osoyoos Lake currently limit Okanagan sockeye population levels.

Recommendations supported by the paper are that: 1) minimum escapement objectives for Okanagan sockeye be set at 58,730 adults (in Wells Dam count

units) or 29,365 adults as peak visual counts on the spawning grounds, 2) biological consequences of smolt size management of Osoyoos Lake sockeye be explored as a requisite to refining escapement objectives that might be adopted if Okanagan sockeye stock rebuilding is successful in future years, 3) annual sampling for size and age composition of Okanagan sockeye smolts be completed whenever feasible to facilitate future analysis of smolt-to-adult survival trends and smolt size management options in Osoyoos Lake, 4) annual sampling for age, size and sex composition of sockeye in catch and escapement be completed whenever feasible to facilitate future analysis of stock and recruit relations and to follow smolt-to-adult survival trends, 5) retrieval and review of source documentation pertaining to SEDS estimates of Okanagan sockeye escapement plus entry of supplemental comments describing methods used to generate escapement estimates be completed, 6) annual summary estimates of Okanagan sockeye escapement from Wells Dam counts be incorporated into SEDS as a formal alternative to relatively imprecise spawning ground counts and finally, 7) given that neither spawning gravel capacity or lake rearing capacity appear to set the principal limits on Okanagan sockeye population size at current stock levels, additional effort should be expended by the Okanagan Basin Fisheries Working Group to determine the reasons for recent stock declines in the absence of any targetted exploitation of Okanagan sockeye.

Reviewer #1.

Concern was expressed by this reviewer with respect to the accuracy of the counts from Wells Dam, however, the reviewer did feel they were substantially more reliable than estimates provided from other means. The reviewer stressed the lack of differentiation between sockeye and kokanee in spawning ground escapement estimation procedures as a major weakness. It was also noted that the authors should consider the entire spawning area, including the lake outlet, in their description of the weaknesses in the spawning ground escapement estimates.

Distribution of spawners between McIntyre Dam and Osoyoos Lake in high and low flow years requires further investigation according to this reviewer to prove the authors assertion that a fairly constant proportion of spawners utilise the index area. In addition, more information is required regarding the maintenance of stream flows above 380 cfs in order to justify a spawning escapement objective of 57,000.

This reviewer pointed out it may be premature for the authors to suggest that "Limiting Okanagan sockeye escapement levels to maintain production of 100 mm smolts represents a highly conservative position." Several situations were described which may provide alternate theories regarding smolt size and survival to adults.

It was also pointed out that the authors provided no estimates relating to loss of

adults, due to passage through the nine dams between Bonneville and Wells dams.

This reviewer suggested that the proposed minimum escapement objective should be regarded as 'interim' pending additional information.

Reviewer #2.

The authors were commended on the job done in piecing together the information to develop defensible escapement targets despite having no reliable information on returns from brood year escapements.

Concern regarding the ability to differentiate between the smolts produced from Wenatchee and Redfish Lakes and Osoyoos Lake was expressed when using the McNary Dam smolt index. In addition, several questions were raised regarding escapement surveys estimations and possible density dependent relationships.

It was suggested that the PR model (Shortreed et al. S97-09) be used to derive alternative estimates of rearing capacity in terms of maximum smolt biomass. Osoyoos Lake is somewhat atypical of other sockeye lakes and provides an opportunity to test the generality of the PR model.

The reviewer recommended that the suggested escapement objective of 58,730 at Wells Dam be termed an interim target escapement and be rounded to 60,000.

The other recommendations were also supported.

Subcommittee Discussion

A suggestion was made that perhaps a range be provided for the interim escapement objective to reflect the uncertainty of the available data used in the analysis. It was decided that there would be little additional value in doing this because it would only incorporate a portion of the uncertainty.

The Subcommittee noted that there was very limited direct harvest on these stocks. However, the mortalities associated with passage through the dams may prevent these stocks from rebuilding.

There was also concern raised regarding the sockeye/kokanee interactions in Osoyoos Lake and the uncertainty created by the lack of information on abundances of juvenile and adult kokanee. Available evidence suggests that kokanee are not a significant portion of the nerkid population.

The Subcommittee stressed the importance of escapement information and commended the authors on the amount of effort put into reviewing this database.

There was great concern expressed about the state of escapement information throughout the region.

All recommendations provided by the authors were endorsed.

Subcommittee Recommendations

The Subcommittee recommended acceptance of this paper and the interim escapement objective of 60,000 sockeye through Wells Dam (which is equivalent to a historical Osoyoos area visual estimate of 30,000 spawners).

S99-19 Status of coho salmon stocks adjacent to the Strait of Georgia, including the lower Fraser River

K. Simpson, R. Semple, S. Bailie, B. Adkins, S. Lehmann **Accepted subject to revisions**

Summary

Lower Fraser and Vancouver Island indicators continue to show different patterns of ocean survival, escapements and possibly smolt production. There is insufficient information to define the situation on the Sunshine Coast/Howe Sound. Escapements in 1997 were improved but still well below recent averages and this was reflected in below average fry densities in 1998. Probably due to dry summer conditions, the fry were not correspondingly large and smolt numbers may be low again this spring. Smolt runs on Vancouver Island were probably below average to well below average in 1998. Coupled with a forecast of continued poor ocean survival (Working Paper S99-2) the abundance of adult coho from the east coast of Vancouver Island is expected to be very poor in 1999.

Although there is some evidence for reduced recruitment to the ocean, it is clear that continuing poor ocean survivals are driving the low abundances. 1997 and 1998 were the third and fourth consecutive years of 'outside' distribution by Georgia Basin coho. The survival of coho in the northern Basin stabilised in 1995-96 while survivals of middle and southern Basin stocks continued to decline. Survivals, although poor, are now better at the north end than to the south. This was apparent in the 1998 escapements. Spawner numbers were probably adequate in SE Vancouver Island and on the Lower Mainland but they have responded sluggishly to the near cessation of exploitation. In the Lower Mainland, both smolts and adults have been relatively stable over the last four years, based on two wild coho monitoring projects. This stabilisation of smolts and adults in one of the indicator stocks, Salmon River (Langley), is at a level much below that seen in the 1980's. Recent declines in survival of Salmon River coho up to 1998 appeared as lower exploitations/catches rather than reduced escapements, which we cannot explain. The 1998 escapement to both streams

actually declined despite the virtual cessation of fishing, another signal that abundances of some Lower Mainland stocks are very low.

Survivals of hatchery coho, normally not as good as wild survivals, were again poorer in 1997 and 1998, putting them at critically low levels in 1998 of only 0.2 to 1.0 percent. The effect on survival of ventral clipping this brood was equivocal.

There are conflicting signals coming from the Lower Mainland data and another wild indicator stock project would be helpful. A wild indicator further north on the mainland remains a pressing need. The fry survey as conducted in the Basin now appears to be useful in estimating parental escapements. Its economy allows us to survey more streams than other techniques. Fry data will aid us in defining the sample needed to accurately monitor stocks in the Lower Mainland and throughout the Basin.

Reviewer #1

The first reviewer felt that the paper succeeds in providing an update on trends in population and exploitation data. He indicated that although results from coho fry sampling are presented, the information on the reliability of these data, and what trends in fry abundance means is too brief to properly assess. He indicated that the paper is not a true "assessment" because there are no standards to evaluate the current status of the stocks, except by comparison to historical abundance levels. He noted that agreed-upon guidelines for defining coho stock status are required.

Review #2

The second reviewer felt that the crux of the assessment was the analysis of trends in fry densities and agreed with the authors that a review of the methodology is necessary. He was particularly concerned with the adult escapement estimates produced using Area Under the Curve (AUC) methods. He felt that more information on how AUC parameter estimates were derived was necessary to have confidence in the estimates produced. He also suggested more quantitative, rather than descriptive, analysis of the relative status in each of the indicators (e.g. fry density, fry size, escapement, etc.).

Both reviewers suggested that the conclusions could be clearer, to which the authors agreed and a revised set of conclusions was tabled during the presentation.

Subcommittee Discussion

The Subcommittee discussed the AUC estimation procedures, the effects of straying between adjacent streams and the effects this could have on exploitation

estimates, and the role of enhancement at times of low marine survival and low wild coho production.

The Subcommittee discussed the need for a review of enhancement strategies related to coho salmon in the Strait of Georgia, as there are divergent views on the utility of enhancement when stocks are at current low levels.

The Subcommittee identified the need for a review of all aspects of the juvenile coho assessment programs. As identified in previous PSARC reports there remains a need for other coho indicator streams in the Strait of Georgia, particularly in the Lower Fraser River and the Mainland coast area.

The Subcommittee noted that there was a record poor brood year escapement in 1996, which probably produced low numbers of smolt in 1998. Even if marine survival was average or above, low production of adults would be expected. As forecasts of survival are below average for returns in 1999, the outlook for returns in 1999 is very poor. Marine survival is the driving influence for adult production and it continued to decline in the Southern Strait of Georgia. Escapements responded strongly to cessation of directed fishing in the Northern Strait of Georgia, responded sluggishly in the Southern Strait and did not compensate for natural mortality in the Lower Fraser River area. Unless there is a reversal in ocean conditions, the risks and conservation concerns for Strait of Georgia coho stocks will be even higher in 1999 than in 1998.

Subcommittee Recommendations

The Subcommittee recommended that given the current low productivity of the Strait of Georgia-lower Fraser River coho aggregate, fishing mortality must be kept to a minimum to conserve and maximise the potential to rebuild these stocks.

S99-20 Status of clockwork chum salmon stocks and review of the Clockwork Management Strategy

P. Ryall, C. Murray, V. Palermo, D. Bailey, D. Chen **Accepted subject to revisions**

Summary

This paper is a continuum in the assessment of clockwork chum stocks and the corresponding fishery management. The purpose of the paper is to provide: 1) an up to date stock-recruit analysis, including the large returns up to 1997, for both Fraser and non-Fraser clockwork stocks. This analysis focused on wild stocks but an assessment of enhanced components is also presented, 2) and updated assessment of escapement patterns, 3) an updated assessment of the Mission fry estimates and it's relationship to subsequent returns, 4) a retrospective

analysis of in-season run size estimates in Johnstone Strait and 5) a review of the fishery management (1983 through 1997) with respect to the effectiveness of the Clockwork management plan.

S-R analysis was done on 1959-1992 brood years for wild Fraser and non-Fraser wild Clockwork chum. Results show that for Fraser chum, the optimal harvest rate is approximately 45% which is almost identical to that found by Joyce and Cass (PSARC 92-02), however, unlike that earlier report, the optimal stock size was found to be 738,690 which is substantially greater than 485,320 estimated by Joyce and Cass. Further, evidence of density dependence was found for Fraser stocks that was not found in earlier work. For the aggregate wild stocks, the optimal harvest rate was 44% with optimum stock size calculated at 2.6M. Evidence for density dependence was also noted.

Chum escapement patterns and production has varied based on stock. As an overall aggregate view, production has increased however it is noted that some stocks appear to be decreasing in spite of management and conservation actions. There is a need to standardize data collection methods to improve escapement estimates. Increased escapement for ISC chum need to be done to stop marked declines in escapement. Fraser River chum stocks have shown greater production and increased escapement and are driving the aggregate.

Heuristic analysis of the predictive ability has shown that although the mission downstream data correlates with subsequent stock size, it is still too variable to be considered a useful tool for prediction.

Six models were tested and analyzed as to their utility value for in season stock size estimation. In general, no one model performed markedly better than any other and although run size estimates have been reasonably accurate in comparisons to the final run size, there have been a number of years where the in-season and final estimates have been significantly divergent.

Where viewed from an aggregate viewpoint and taking the associated uncertainties into account, we conclude that the Clockwork management regime has worked reasonably well in meeting escapement and harvest rate targets and therefore should continue.

The results of our study would indicate that overall the Clockwork management has been successful in achieving a number of its objectives. Namely the strategy has allowed for limited commercial fishing in most years, increased wild escapement levels overall, and helped to increase our understanding of the optimal target escapement levels. That said, there remains significant concern over the level of escapement enumeration and accuracy of the escapement estimates upon which the Clockwork strategy and this stock status review depends. We believe significant improvements are required for chum escapement enumeration. We have noted earlier in this document that this is

occurring in some areas and we strongly support the continuance and development of those programs. In 1998, preliminary escapement estimates to the Fraser River are in the order of 3.4 million and significantly greater than the current target of 700,000. The in-season Albion test fishery escapement estimate of 1.4 million was less than 50% of the post-season. This apparent disparity between the two should cause concern for managers of Fraser River chum. We recommend that a PSARC review of the programs used to estimate Fraser River escapement is required.

While there is a general increase in wild escapement levels, it would appear that not all areas have responded equally. Specifically, escapement records to Upper Vancouver Island, Kingcome Inlet, Bond and Knight Inlets and Toba inlet show apparent declines to escapement levels. We caution in arriving at the conclusion that over harvest is the cause of the decline. Other factors such as lack of escapement enumeration effort to some of these areas and possible habitat issues may be the agent and this needs to be explored in greater detail.

The current wild escapement goal is set at 2.0 million. The Clockwork management plan called for reaching the interim goal of 2.5 million in 12-15 years or 1995-1998. Results from the present stock-recruit analysis suggests the Smsy level is 740,000 (479,000 – 2,482,000; 80% CL) for Fraser River chum. Recent record escapement will allow us to test this conclusion in the near future. At this time, we recommend no change to the current minimum escapement target for Fraser River of 700,000. With respect to the overall goal our analysis was significantly divergent from Beacham's (1984). This result is not surprising given the increase in the number of years available for inclusion in our analysis. Anecdotal information would suggest that the 1985 brood year should be removed from the analysis due to atypical freshwater mortality and thus the high escapement in 1985 produced extremely low recruitment. When the 1985 brood was removed from the analysis the estimate of optimal escapement was 2.4 million. As we have 4 more years (1993-1996 and 1998) of estimated escapement above or near 2.0 million that cannot as yet be included in the analysis we recommend leaving the wild escapement goal at 2.0 million until such time these additional years can be included.

Finally, while in-season estimates of run size have provided reasonably accurate estimate in comparison to the final run size estimates. There have been a number of years where the in-season and final estimate were significantly divergent. The current models are dependent upon the assumption of average migratory timing of the Clockwork chum stocks. In-season models based upon average migratory timing will under or over-forecast population abundance's because of run timing variability. Recent analysis that incorporates a run timing variable (Zheng and Mathisen, 1998) found greatly improved run size forecasts for south-eastern Alaska pink salmon. They found that incorporating sex ratios with their best performing run model improved forecasts by 30% over the best model without sex ratios. We have been collecting sex ratio data for chum

Clockwork stocks since 1993 and preliminary analysis indicates that there is a correlation between sex ratios and run timing as observed by the Johnstone Strait chum test fishery vessels. Therefore, we recommend that further analysis be considered to incorporate sex ratio data into the in-season run size models.

Reviewer #1

The first reviewer recommended some edited and restructuring to improve the paper. The reviewer noted that the completion of the chum Clockwork system database greatly facilitated the data presentation and analysis. The reviewer recommended the Subcommittee specifically consider the need for improved escapement enumeration.

Reviewer #2

The second reviewer stated the paper was a detailed description of the status of chum stocks and a review of the Clockwork management program for chum. The need for improvements to the organization of the paper was noted. The reviewer indicated the data and methods were sufficient to support the conclusions, and the recommendations should be straightforward and useful to managers. A review of the discrepancy between the Fraser in-river test fishery and the on grounds escapement estimates needs to be reviewed.

Subcommittee Discussion

The Subcommittee concurred with the authors' conclusion that overall Clockwork management has been successful at creating commercial fishing in most years and increasing spawning escapements to terminal areas in the large chum systems. The Subcommittee agreed that the recent degradation of the accuracy and consistency of escapement estimates is seriously undermining the potential to evaluate Clockwork management. Discussion focussed on the need for a review of Clockwork management and to explore other potential harvest management models.

Management within terminal areas was deemed the responsibility of terminal harvest models. Within the terminal Fraser area, the ability to predict terminal area abundance is seriously degraded. The in-season Albion test fishery escapement index and spawning ground escapement estimates are no longer sufficiently correlated to adequately support in-season terminal fisheries management. Concerns about Fraser mark-recapture estimates of spawning escapement, particularly for Harrison Chum, should be examined. Other inconsistencies include apparent changes in the structure of early and late-timed runs to the Fraser that cannot be monitored with existing programs.

Although there has been overall increases in wild escapement levels, the apparent long-term decline in escapements to Upper Vancouver Island,

Kingcome, Bond, Knight and Toba inlets and the apparent decline in wild late season escapement to the Fraser River is of concern. The reason for the downward trend in the data is not clear.

The Subcommittee noted that optimal harvest rates from a Ricker stock-recruit analysis in the paper was 46% for the Fraser stocks (1959-92 brood years) and 45% for the ISC (1955-93 brood years). Average exploitation rates were 37% for the Clockwork management plan for the period (1983-93). Stock-recruit analysis on Fraser Chum conducted during the meeting using SRshow software (Carl Walters, University of British Columbia, personal communication) indicated the optimal exploitation rates using a Ricker recruitment model that accounts for uncertainty using the Bayes posterior distribution (brood years 1959-92) was 42%.

Based on PSARC Working Paper S92-02, PSARC recommended the Fraser chum escapement target be increased to a minimum of 800,000 naturally spawning chum. At that time it was concluded the optimal escapement for the Fraser chum aggregate would not be known without probing at escapement levels ≥ 800,000 natural spawners. Escapements beyond 800,000 chum have occurred since the original PSARC advice. The Subcommittee noted that new information on spawning capacity will become available when progeny from the high escapements return over the next few years. This should help define the productivity of the Fraser chum aggregate.

There is little evidence for diminished returns at high spawning escapement based on stock-recruit analysis for wild Fraser chum. The escapement target of 700,000 Fraser River chum cannot be endorsed because it is inconsistent with previous PSARC advice that recommended a minimum escapement target of 800,000 naturally spawning chum (PSARC Working Paper 92-02). The Subcommittee recommended that the revised PSARC minimum target escapement of 800,000 natural spawners for Fraser chums be applied.

Aspects of the Fraser Clockwork management system still need to be reviewed. Concern was expressed regarding the adequacy of the current Fraser terminal Clockwork system, particularly 1) the adequacy of the in season test fishery model to track stock abundance and 2) the methodology of escapement enumeration on the Chehalis/Harrison system.

Subcommittee Recommendations

1) The Subcommittee recommended that the current overall ISC wild chum escapement goal of 2.0 million spawners remain in place.

2) The Subcommittee recommended that the previously revised PSARC target escapement of 800,000 Fraser chum natural spawners be applied.

3) The Subcommittee recommended the review of 1) the adequacy of the In Season test fishery model to track stock abundance with an objective to find a more suitable protocol if the current model is deemed to be a failure. 2) the methodology of escapement enumeration on the Chehalis/Harrison system to ensure that unbiased and representative escapement enumerations are indeed being generated.

S99-21 Spawning capacity and harvest policies for Fraser River sockeye

A. Cass, J. T. Schnute, L. Richards, A. MacDonald **Accepted subject to major revisions**

Summary

The purpose of the paper is to review recent production trends, assess spawning capacity limits for 11 stocks and present a method for evaluating alternative long-term management objectives for Fraser sockeye. Sockeye spawning escapement to the Fraser River gradually increased from an average of 1.5 million fish/yr. in the 1950s to 10.7 million/yr. during 1980-97. Much of the increase in the 1980s and 1990s has been on the 1993 and 1994 cycle lines. The 1995 cycle has increased slightly and the 1996 line has persisted at low levels. Increases in escapement mainly have occurred in the large actively managed stocks and cycle lines (Early Stuart Late Stuart, Quesnel and Late Shuswap). Returns of adult sockeye increased nearly two fold from an average of 6.4 million sockeye/yr. in the 1950s to 11.3 million fish/yr. in 1980-97. This increase occurred mainly from fisheries intervention that reduced harvest rates in some of the poor return years and probed opportunistically at high escapements in years of good returns. The temporal pattern of returns varies considerably among stocks. For Early Stuart and Stellako sockeye, the estimated annual returns have varied without a persistent overall trend since the 1950s but have increased since the mid-1980s. The 1996 Early Stuart off-cycle increased since 1988. Late Stuart, Chilko, Quesnel, Seymour, Late Shuswap and Birkenhead sockeye returns have been increasing in recent years. For the highly cyclic Quesnel stock, returns have increased on all four cycles. This has not been the case for the Late Shuswap stock whereby the off-cycle lines have remained at low levels. The relatively small Bowron, Raft and Cultus stocks show persistent declines in annual returns. Fraser sockeye have been remarkably productive rarely dropping below the replacement level (R/S=1). Summing across all stocks and years, each spawner produced a mean of 5.1 recruits.

The stock-recruit analysis that captures uncertainty using a Bayes perspective shows that estimates of the stock productivity parameter are well defined, however, spawning capacity that maximizes MSY is poorly defined for most of the 11 stocks considered. Methods for evaluating effects of long-term management objectives were presented to illustrate the progress to-date. An example of the analysis based on a single stock fishery was presented. An

objective or value function was employed to assess the performance of objectives. The value function depends on the catch sequence that, for example, can includes penalties attached to years in which the fishery drops to low levels. The value function could be tailored to favour either conservation or high exploitation depending on societal values. We consider a two-policy space dependent on a minimal target escapement and catch removal fraction above the target. Policy outcomes were assessed using a retrospective analysis that preserves the historical recruitment survival pattern. This has intuitive appeal for policy evaluation because it shows what might have happened if a particular policy was applied throughout the recorded history. Our example of a single-stock policy evaluation needs to be expanded to consider realistic mixed-stock fishery situations that appropriately deals with ways to protects small stocks in the mixture (i.e. production-based versus conservation-based strategies). Contour plots of policy outcomes over a range of policy space are useful for evaluating long-term management objectives.

Review #1

The reviewer indicated that this paper provides a useful review of stock status and trends, and utilizes Bayes statistical methods that provide a clearer picture of uncertainty for the stock-recruit models that have been used for recent policy analysis. The retrospective method for comparing feedback choices is a reasonable way to compare such choices, though as the authors' note it is very unlikely that the best policy is a stationary T-h rule in the first place. The reviewer disagreed with the authors about where to go next. Differences between Stuart/Quesnel cyclic rebuilding and Shuswap, and evidence from limnological studies and Alaskan experience, imply that it may be extremely dangerous to continue using simple uncertainty about S^* as evidenced from traditional stock-recruitment analysis to drive a policy of continuing to "experiment" with dominant and sub-dominant cycle lines.

The reviewer's main concern with the analysis was that the authors state that a test of dominant/subdominant line rebuilding began in 1987. The recommendations by Collie and Walters, and later by Welch, were quite specific that the rebuilding experiment should target off-cycle lines. Based on extended stock-recruit models with S_{t-1}, S_{t-2}, etc. terms along with S_t, they concluded that there did appear to be some statistical basis for concern about "cyclic dominance" (cross-cycle line suppression of productivity), and urged that experimentation avoid the possibility of this effect (on off cycle lines) by not rebuilding dominant and subdominant lines. They further warned that dominant/subdominant productivity should be monitored closely for evidence of impact from rebuilding off-cycle lines.

The reviewer agreed that there is still extreme uncertainty about S^* for many stocks and that the rebuilding experiment has been a great "success" to date. It is time to look much more carefully at the dynamics of freshwater production and

cross-cycle line linkages, and to target future data analysis, modeling, and experimental policy design specifically on this issue. High priority should be put on decision analyses that recognize risk of strong cross-line negative impacts at high spawning stock sizes.

Review # 2

The reviewer indicated that in general this is an excellent paper that demonstrates a thorough understanding of the topic, the issues and the methodologies. The reviewer's comments arise more out of frustration that many of the important questions surrounding this topic have not yet been pursued by the scientist and managers responsible for these stocks. These stocks are of singular importance. The nature and scale of the experiment that was started over a decade ago demands a full and complete assessment. While this paper is an excellent start, it only addresses a small part of this complex issue.

The purpose is clearly stated in the introduction "This paper documents and evaluates the rebuilding policies of the last ten years." Unfortunately, the paper falls short of fully documenting the policies or evaluating them in the context of the grand experiment that was suggested by the policies. "In 1987, Canada embarked on a stock rebuilding policy designed to test production capacity limits at higher spawning stock sizes mainly on dominant and subdominant cycle lines." The paper does not document the policies, nor does it provide any detail on the policies that existed prior to 1987. To evaluate the policies a question we need to ask is whether our understanding of the production capability and management prescriptions are different now than if the "new" policies had not been implemented?

The reviewer could not find any conclusions in the conclusion section other than more work needs to be done. Nor could the reviewer find any specific well-defined recommendations that are easily accessible to fishery managers. The suggestion that a fixed harvest rate policy in the 60% range is useful but it depends on particular value functions and may not be directly applicable without a substantial amount of supporting analysis.

Does the advice reflect the uncertainty in the data, analysis or process? Yes, the advice in this paper is that there is a great deal of uncertainty and there needs to be more analyses.

The paper does not go far enough in evaluating the policies of the last decade. One analysis that should be done is to evaluate the policy prescriptions and present values of implementing those prescriptions based upon information gained from the "experiment", as compared to what the prescriptions and values would be if the policy had not been implemented, the "control". In other words, has the experiment resulted in an improved or different understanding of the productivity of the stocks and has there been any change in our assessment of

the value of the stocks as a result of any improved knowledge?

Subcommittee Discussion

The Subcommittee had an extensive discussion about the objective of this paper, and the lack of conclusions or recommendations in the paper. As identified by one reviewer, the paper did not "evaluate the rebuilding policies of the last ten years" but provided another overview of the current stock status and time trends in production. The strength in this assessment was its treatment of uncertainty (Baysian methods) and the preliminary development of a policy evaluation framework. The Subcommittee did question why the implementation of the "rebuilding policy" was not evident in the time trends of harvest rates or escapements.

The authors acknowledged that this was a "work in progress" and not a review of the Fraser sockeye rebuilding strategy. The paper did not contain explicit recommendations for managers other than an awareness of the uncertainty in the production limits for Fraser sockeye.

The Subcommittee accepted the paper on the merits of the methods developed and up-date of the production dynamics of these important stocks. However, stock-specific values such as the S* and h* at MSY in Table 2 of the working paper, are not recommended for implementation without a more comprehensive assessment of the rebuilding program and Regional consultation. The Subcommittee noted the need for several papers for development of a comprehensive management plan for Fraser sockeye salmon:

a) A historical review and evaluation of the "rebuilding policy" implemented in 1987,

b) an assessment of the trade-off implicit between managing for production from the major stocks and diversity at risk among the numerous smaller populations,

c) assessment of Limit Reference Points for conservation of these populations (this paper did not assess conservation goals),

d) a critical examination of potential cycle interactions and the effect these would have on policy assessments for future experimental management, and

e) more comprehensive assessments of harvest policy options, evaluation criteria, and user and stock concerns (e.g., mixed-stock fishery impacts if harvests are driven by larger populations, or definition of policy evaluation criteria).

Subcommittee Recommendations

The Subcommittee supported development of a work plan to address these issues.

APPENDIX 1: PSARC SALMON SUBCOMMITTEE MEETING AGENDA, MAY 3-7, 1999

Start Time	3 May	4 May	5 May	6 May	7 May
8:30		S99-15 Taku Chinook Assessment	S99-10 WCVI Coho Assessment	S99-17 Kitsumkalum Chinook Indicator Review	Subcommittee review of rapporteur reports
10:30		S99-16 Stikine Chinook Assessment	S99-9 Thompson Coho Assessment	S99-11 Recreational Hooking Mortalities	
12:00-13:00	LUNCH	LUNCH	LUNCH	LUNCH	LUNCH
13:00	S99-21 Fraser Sockeye Policy Evaluation	S99-13 Cowichan Chinook Enhancement Impacts	S99-19 St. Georgia Coho Assessment	S99-12 Skeena Coho Assessment	
15:00	S99-18 Okanagan Sockeye Assessment	Discussion on chinook escapement targets		S99-20 Chum Status and Clockwork	

APPENDIX 2: PSARC SALMON WORKING PAPERS FOR MAY 1999.

No.	Title	Authors	Reviewers
S99-9	1999 Assessment of Thompson River/Upper Fraser River Coho Salmon	J. Irvine R.E. Bailey M.J. Bradford R.K. Kadowaki W.S. Shaw	K. Wilson T. Gjernes
S99-10	Assessment of Coho Stocks on the West Coast of Vancouver Island, 1998	S. Baillie B. Patten J. Till K. Simpson W. Luedke P. Tschaplinski	J. Irvine D. Meerburg
S99-11	A review of hooking mortality rates for marine recreational coho and chinook salmon fisheries in British Columbia	S. Cox-Rogers T. Gjernes E. Fast	P. Ryall B. Otway
S99-12	Biological assessment of Skeena River coho salmon	B. Holtby B. Finnegan D. Peacock	R. Kadowaki A. Tautz
S99-13	Enhancement impacts on Cowichan River chinook	R.G. Bonnell S. Lehmann D. Nagtegaal	C. Cross K. Simpson
S99-15	Optimal production of chinook salmon from the Taku River	S.A. McPherson D.R. Bernard J.H. Clark	B.Riddell L. Jantz
S99-16	Optimal production of chinook salmon from the Stikine River	D.R. Bernard S.A. McPherson K.A. Pahlke P. Etherton	D. Chen S. McKinnell
S99-17	An assessment of Kitsumkalum River summer chinook, a north coast indicator stock	R. E. McNicol	D. Bailey B. Spilsted
S99-18	An evaluation of Okanagan sockeye escapement objectives	K. Hyatt D.P. Rankin	C. Wood B. Green

No.	Title	Authors	Reviewers
S99-19	Status of coho salmon stocks adjacent to the Strait of Georgia, including the lower Fraser River	K. Simpson R. Semple S. Baillie B. Adkins S. Lehmann	W. Luedke M. Bradford
S99-20	Status of clockwork chum salmon stocks and review of the Clockwork Management Strategy	P. Ryall C. Murray V. Palermo D. Bailey D. Chen	D. Anderson L. Hopwo
S99-21	Spawning Capacity and harvest policies for Fraser River Sockeye	A. Cass J.T. Schnute L. Richards A. McDonald	M. Staley C. Walters

APPENDIX 3: PARTICIPANTS AT SALMON SUBCOMMITTEE MEETING, MAY 3-7, 1999.

Subcommittee Chair: Dave Peacock
PSARC Chair: Max Stocker

DFO Participants	Mon	Tues	Wed	Thurs	Fri
* Subcommittee Members					
J. Irvine*	✓	✓	✓	✓	✓
M. Sullivan*	✓	✓	✓	✓	✓
D. Meerburg*	✓	✓	✓	✓	
S. Argue*	✓		✓	✓	
D. Bailey*	✓	✓	✓	✓	
P. Ryall*	✓				
J. Schnute	✓				
b. Riddell*	✓	✓			
Al Cass*	✓	✓		✓	✓
Al MacDonald*	✓				
M. Bradford*	✓	✓	✓	✓	
L. Jantz	✓	✓	✓		
K. Hyatt*	✓				
D. Anderson*	✓			✓	
C. Wood*	✓			✓	✓
R. Kadowaki*	✓			✓	
D. Chen		✓		✓	
S. Cox-Rogers		✓	✓	✓	
R. McNicol		✓		✓	
S. McKinnell*		✓	✓		
K. Simpson			✓		
R. Semple			✓		
R. Bailey			✓		
B. Snyder			✓		
B. Patten			✓		
J. Till			✓		
B. Finnegan			✓		
D. Beamish			✓		
J. King			✓		
B. Hargreaves*			✓		
B. Shaw			✓		
D. Ware			✓		
D. Rutherford				✓	
B. Holtby*				✓	

External Participants:

A. Tautz*	✓	✓	✓	✓	
R. Routledge	✓	✓	✓	✓	
M. Chatwin	✓		✓		
C. Walters	✓	✓	✓	✓	
W. Harling	✓		✓	✓	✓
L. Rombough	✓				
B. Rezansoff	✓	✓	✓	✓	
K. Wilson	✓	✓	✓	✓	
M.S. Atkinson		✓	✓	✓	
C. Walters		✓	✓		
D. Bernard		✓			
S. McPherson		✓			

Observers

M. Staley (Reviewer)	✓				
M. Hunter	✓				
M. Couswold	✓				
L. Godbout					
K. Scarfo	✓		✓	✓	
D. Blackbourn	✓		✓		
P. Sakich		✓			
G. Morishima		✓	✓		
K. Scarfo		✓			
B. Tweit			✓	✓	
B. Otway (Reviewer)					